Trench width dependant deeply etched surface-defined InP gratings for low-cost high speed DFB/DBR

Trench width dependant deeply etched surface-defined InP gratings for low-cost high speed DFB/DBR lasers

Sohaib Afzal [a], Florian Schnabel[a], Wenzel Scholz[a], Johann Peter Reithmaier[a], Marco Vallone[b], Ivo Montrosset[b]

[a] Institute of Nanostructure Technologies and Analytics (INA), University of Kassel, 34132 Kassel, Germany
[b]Politecnico Di Torino, Dipartimento di Elettronica, 10129 Torino, Italy
e-mail: afzal@uni-kassel.de

Keywords: Deeply etched InP gratings, 1.55µm DFB Telecommunication laser, Trench width dependant etching, ICP-RIE process for InP

Development of high speed DBR/DFB lasers is the focus of current research work in the field of optoelectronics for tele- and data-communication. Different fabrication techniques are being implemented with some trade-offs; either they are not fast enough for future 100 GBit Ethernet or the devices become too expensive.

In this paper we are reporting a fabrication process for multi-section telecom lasers based on surface defined lateral gratings, which is compatible with low-cost high-throughput nano-imprint lithography. A new grating definition process is developed, which allow a better control of the cross section geometry to obtain higher coupling strengths.

To overcome anisotropic etch rates in partially opened trench structures, like lateral gratings, the grating structure can be surrounded by semiconductor material only separated by a thin trench [1]. However, in this case only thin dielectric layers can be used for electrical insulation to the device contacts, which leads to high capacitance and high RC time constants. For this purpose a design was chosen, which allow both, a trench width control of the etching rate and the deposition of thick insulation layers.

Figure 1 shows the cross sectional schematic diagram of the new approach, which consists of rather thin additional sidewalls, which are reduced in height during the etching process. Due to the improved uniformity of the etching rate the cross section is more rectangular and sharp corners are formed as can be seen in the focused ion beam (FIB) cut shown in figure 2.

Due to the higher etch rates outside the grating structure, an effectively wider waveguide is formed, which in principle allows the guiding of several higher order modes. In figure 3, the coupling coefficient of different lateral modes are plotted as function of the width d of the additional lateral walls. For thin walls (d < 500 nm) the TE01 mode is dominating with coupling coefficients up to 100 cm^{-1}, while for thicker walls (d > 1 µm) the fundamental mode TE00 is dominating with a coupling strength of more than 60 cm^{-1}, which is an improvement by a factor of 3 to previous designs with lateral gratings [2]. A final grating structure can be seen in figure 4 with smooth surfaces, vertical profiles and dummy side walls.

Devices are currently under process and more results will be presented in the conference.

Acknowledgement:
This work was supported by the European Commission through ICT project DeLight [3].

References:
[1] Mihail Dumitrescu, ORC, Tampere University, Finland.
[2] S. Afzal, F. Schnabel, W. Scholz, J. P. Reithmaier, D. Gready, G. Eisenstein, P. Melanen, V. Vilokkinen, I. Montrosset and M. Vallone, " 1.3 µm two-section DBR lasers based on surface defined gratings for high-speed telecommunication ," IEEE Photon. Technol. Lett. vol 23, No. 7, pp 411-413, April 2011.
[3] www.delightproject.eu

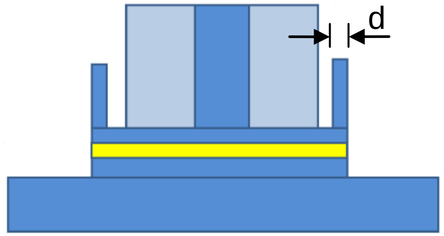

Figure 1. Cross sectional schematic diagram of the laser design with dummy side walls.

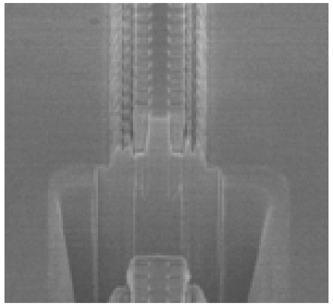

Figure 2. FIB cut through of the grating structure showing very rectangular profiles.

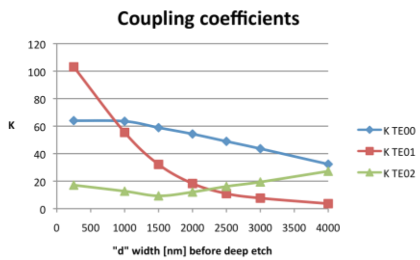

Figure 3. Simulation results showing higher coupling coefficients for smaller wall width.

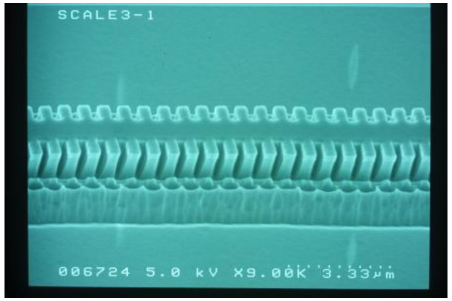

Figure 4. SEM image of smooth vertical gratings with narrow and shallow dummy side wall.